

EXHAUST GAS RECIRCULATION SYSTEM FOR  
INTERNAL COMBUSTION ENGINE

## BACKGROUND OF THE INVENTION

### Field of the Invention

The present invention relates to an exhaust gas recirculation system (EGR system) for an internal combustion engine.

### Description of the Related Art

In general an exhaust gas recirculation system for an internal combustion engine has such a configuration that EGR gas to be recirculated is extracted from an exhaust port in a cylinder head and is led into an intake passage, downstream of a throttle valve, by way of an EGR valve.

In the exhaust gas recirculation system having the above-mentioned configuration, when an intake manifold is made of resin, for preventing thermal deformation of the resin manifold caused by EGR gas at a high temperature, a metal spacer (plate) is interposed between the resin intake manifold and the cylinder head of the engine, and an EGR gas passage is formed in the spacer portion.

As a conventional structure forming the EGR gas in the spacer portion, as shown in Fig. 12, an EGR branch passage 102 which is recessed in a spacer 101 and through which EGR gas flows upward is disclosed, for example, in JP-A-2000-8968.

As the above-mentioned conventional exhaust gas recirculation system, in the configuration that the EGR branch passage 102 in the spacer 101 is curved downward in a state of installation, condensed water from steam in EGR gas collects at a bottom portion 103 of the EGR branch passage 102, and there would be caused a risk of corrosion of the spacer 101 due to aging effect since the condensed water is acid.

#### SUMMARY OF THE INVENTION

10 Accordingly, it is an object of the present invention to provide an exhaust gas recirculation system for an internal combustion engine which can solve the above-mentioned problems.

In order to solve the above problems,  
15 according to the present invention, there is provided an exhaust gas recirculation system for an internal combustion engine, in which at least a metal plate is interposed between a cylinder head and a intake manifold made of resin, and an EGR gas passage is  
20 formed in the plate, characterized in that:

an EGR gas outlet port communicated to an intake passage formed in the plate is provided and located at the lowest portion in the EGR gas passage formed in the plate.

25 With this configuration according to the present invention, when condensed water from steam in EGR gas attaches to the EGR gas passage formed in the

plate, the condensed water flows down to the lowest portion of the EGR gas passage, due to the stream of the EGR gas, and is then discharged into the intake passage through the EGR outlet port formed in the above  
5 lowest portion. Thereby it is possible to prevent the condensed water from collecting in the EGR gas passage.

In the present invention, further, the bottom surface of the EGR gas passage may be formed therein with an inclined surface which slopes downward to the  
10 side where the EGR gas outlet port is located, in the for and aft direction of the plate.

With the above configuration, the condensed water in the EGR gas passage can be led into the EGR gas outlet port even though the plate is inclined in  
15 its for and aft direction when the plate is attached to the cylinder head, thereby it is possible to surely discharge the condensed water.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a plan view illustrating an  
20 internal combustion engine incorporating an exhaust gas recirculation system according to a first embodiment of the present invention;

Fig. 2 is a perspective view illustrating a condition in which an intake manifold, a plate and a  
25 gasket shown in Fig. 1 are superposed with one another and are temporarily fixed;

Fig. 3 is an exploded perspective view

illustrating the components shown in Fig. 2;

Fig. 4A is an enlarged perspective view illustrating a first plate shown in Fig. 3;

Fig. 4B is an enlarged perspective view  
5 illustrating a second plate shown in Fig. 3;

Fig. 5 is a rear view of the first plate shown in Fig. 4A;

Fig. 6 is a front view of the second plate shown in Fig. 4B;

10 Fig. 7A is a sectional view taken along a line VIIA-VIIA in Fig. 5, Fig. 7B is a sectional view taken along a line VIIB-VIIB in Fig. 6, and Fig. 7C is a sectional view illustrating the plates shown in Figs. 7A and 7B are superposed each other in a state of  
15 installation;

Fig. 8A is a sectional view taken along a line VIIIA-VIIIA in Fig. 2, and Fig. 8B is a view showing a relationship between bore diameters thereof;

Fig. 9A is a reference sectional view  
20 illustrating a structure shown in Fig. 8A, and Fig. 9B is a view illustrating relationship between bore diameters thereof;

Fig. 10 is an exploded perspective view illustrating a second embodiment according to the  
25 present invention;

Fig. 11 is an exploded perspective view illustrating a third embodiment according to the present invention; and

Fig. 12 is a front view illustrating a spacer in a conventional configuration.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

Explanation will be hereinbelow made of preferred embodiments according to the present invention with reference to Figs. 1 to 11.

Figs. 1 to 8 show a first embodiment according to the present invention.

Referring to Fig. 1 which is a plan view illustrating an internal combustion engine incorporating an exhaust gas recirculation system according to the present invention, an intake manifold 3 made of resin, a first plate 4 made of metal, a first metal gasket 5, a second plate 6 made of metal and a second metal gasket 7 are interposed between intake tube portions 1 and a cylinder head 2 of the engine, in the mentioned order. There is also shown an EGR valve 8 in this drawing.

Detailed explanation will be made of the components as mentioned above with reference to Figs. 2 to 8B.

The resin intake manifold 3 has a flange portion 3a which is formed in a sidewise long shape so as to have four intake passages 9 for cylinders in a multi-cylinder engine, that is, four cylinders as shown in the drawing, and the intake passages 9 are communicated, on the front surface 3b side, with the

intake tube portions 1 by means of coupling portions 10, and are opened on the rear surface 3c side.

The above-mentioned first plate 4 is formed so as to have its outer periphery which defines a shape coincident with the outer peripheral shape of the flange 3a of the above-intake manifold 3, and is formed therein with four intake passages 11, piercing therethrough and opened to both front surface 4a and rear surface 4b thereof, at the positions of the intake air passages 9. Further, the first plate 4 is formed thereon with a mounting portion 4c for the EGR valve 8 on one end side. Further, the above-mentioned EGR valve 8 is mounted on the mounting portion 4c on the front surface 4a side through the intermediary of a third metal gasket 12.

Further, the first plate 4 is formed therein with an EGR gas inflow passage 13 which pierces therethrough, and the third metal gasket 12 is formed therein an EGR gas inflow passage 14 which pierces therethrough, which are located at a position where it aligns with an EGR gas inflow passage 15 formed in the EGR gas valve 8. Further, the EGR gas valve 8 is formed therein with an EGR gas outflow passage 16 while the third metal gasket 12 is formed therein with an EGR gas outflow passage 14a which pierces therethrough, and the first plate 4 is formed therein an EGR gas intake port 17 on the front surface 4a side, as shown in Fig. 5, which are located at a position where these passages

are aligned with one another.

The above-mentioned first plate 4 is formed therein with a continuous EGR gas passage 18 on its rear surface 4b side, leaving the wall part by which  
5 the four intake passages 11 are defined, thus, the EGR passage 18 extending along by the intake passages 11 laterally in the plate 4. As shown in Fig. 7A, the EGR gas passage 18 is a blind groove which is not opened at its front surface 4a side but is opened at its rear  
10 surface 4b side, and is formed therein with recesses 18a which descend between the intake passages 11. Further, the EGR gas passage 18 is formed at its one end with an EGR gas intake passage 18b through which the EGR gas passage 18 is communicated with the above-  
15 mentioned EGR gas intake passage 17. The EGR gas intake passage 18b is formed, as shown in Fig. 5, by being inclined so that the portion on the EGR gas intake passage 17 side is located at an upper position.

The above-mentioned second metal gasket 5 has  
20 an outer peripheral shape which is coincident with the outer peripheral shape of the first plate 4, and is formed therein with a communication hole 19 aligned with the EGR gas inflow passage 13 formed in the first plate 4, communication bores 20 aligned with the intake  
25 passages 11, and a communication aperture 21 aligned with the EGR gas passage 18, and a communication aperture 22 aligned with the EGR gas intake passage 18b, these communication hole, bore and apertures



piercing through the second metal gasket 5 so as to extend from the front surface to the rear surface thereof.

The second plate 6 has an outer periphery which defines a shape coincident with the outer peripheral shape of the first plate 4, and is formed therein with an EGR gas inflow passage 23 which is aligned with the EGR gas inflow passage 13 formed in the first plate 4 and with the communication hole 19 formed in the first metal gasket 5, and is also formed therein with intake passages 24 aligned with the intake passages 11 formed in the first plate 4 and with the communication bores 20 formed in the first metal gasket 5, the intake passages 24 piercing through the second plate 6 so as to extend from the front surface to the rear surface thereof.

Further, as shown in Fig. 6, the second plate 6 is formed therein with an EGR gas passage 25 and an EGR gas intake passage 25b on the front surface 6a side, which have shapes coincident respectively with the EGR gas passage 18 and the EGR gas intake passage 18b formed in the first plate 4 and with communication apertures 21, 22 formed in the first metal gasket 5. The EGR gas passage 25 and the EGR gas intake passage 25b are grooves which are opened on the front surface 6a side facing the first metal gasket 5, but are not opened at the rear surface side 6b, as shown in Fig. 7B.

The EGR gas passage 25 in the second plate 6 is formed therein with recesses 25a similar to the recesses 18a in the EGR gas passage 18 in the first plate 4, and each of these recesses 25a is formed at the lowest portion with an EGR gas outlet port 27 which is communicated with one of the intake passages 24, respectively.

Further, each of the recesses 25a has the bottom surface 25c which is inclined downward toward the front surface 6a. Further, the bottom surface 25c has an inclination angle which is set so that the bottom surface 25c is inclined downward to the front surface 6a side with respect to a horizontal plane L even though the first plate 4 is mounted to the engine, being inclined, as shown in Figs. 1 and 7C. Further, each of the EGR gas outlet ports 27 is formed in one of the bottom surfaces 25c on the front surface 6a side where it becomes the lowest position.

The above-mentioned second metal gasket 7 has its outer periphery having a shape coincident with the outer periphery of the second plate 6, and is formed therein with a communication hole 28 aligned with the EGR gas inflow passage 23 formed in the second plate 6, and communication bores 29 aligned with the intake passages 24, the communication hole and bores piercing through the second metal gasket so as to extend from the front surface to the rear surface thereof.

The flange portion 3a of the intake manifold

3 is integrally formed therein at its upper and lower surfaces and fixed thereto with snap pins 29 which are made of resin so as to be elastic and which are projected rearward. When the first plate 4, the first metal gasket 5 and the second plate 6 are superposed on the flange portion 3a of the intake manifold 3, as shown in Fig. 2, the distal ends of the snap pins 29 are resiliently locked to snap pawls 30 which are formed on the upper and lower surfaces of the second plate 6, and accordingly, and thus, they are temporarily fixed together in the condition.

It is noted that the second metal gasket 7 is temporarily fixed in such a way that pins 31 which are formed protrusively on the rear surface 6b side of the second plate 6 are set into pin insertion holes which are formed in the second metal gasket 7 at positions aligned with the pins 31 and are then press-fitted in toothed washers 32 which are provided around the pin insertion holes.

It is noted the above-mentioned components are formed therein with bolt holes 33 for permanently fixing them.

Next, explanation will be made of the temporarily fixing of these components.

The first plate 4, the first metal gasket 5 and the second plate 6 are superposed, in the mentioned order, on the rear surface 6b side of the flange portion 3a of the intake manifold 3, as shown in Fig.

2. After this superposition, the snap pins 29 provided on the flange portion 3a of the intake manifold 3 are snap-fitted onto the snap pawls 30 formed on the second plate 6, and accordingly, these components are temporarily fixed in an integral condition. Further, the second metal gasket 7 is superposed on the rear surface 6b of the second plate 6 while the toothed washers 32 thereof are press-fitted onto the pins 31, and accordingly, the metal gasket 7 is temporarily fixed to the second plate 6. Thus, these components are formed into an unit body (modularization).

Further, the EGR valve 8 is set to the first plate 4 through the intermediary of the third metal gasket 12 by means of a locating pin 34, and accordingly, the EGR valve 8 can be also integrally incorporated thereto.

The above-mentioned components are conveyed to an engine assembling station (engine firm) in the above-mentioned temporarily fixed condition. Since these components are formed in a one unit body during the conveyance, the conveyance can be facilitated.

Further, in the engine assembling station, bolts are inserted through these components held in the temporarily fixed condition, and are fastened to the cylinder head 2, and accordingly, these components are also assembled to the cylinder head 2. The EGR valve 8 is attached thereto by a bolt 35. At this stage, since the components are formed in an one unit body

(modularization), the man-hours for the assembly can be reduced in comparison with such a case that these components are assembled one by one, thereby it is possible to enhance the productivity.

5                   When the engine is driven in such a condition that these components are assembled to the cylinder head 2, EGR gas extracted from the cylinder head 2, flows into the EGR valve 8 after flowing through the EGR gas passages 28, 23, 19, 13, 14 and 15 in the  
10 mentioned order, and accordingly, the flow rate thereof is controlled in the EGR valve 8. Further, the EGR gas flows through the EGR gas outflow passages 16, 14a, and then flows from the EGR intake port 17 formed in the first plate 4 into the EGR gas intake passages 18b, 25b  
15 formed in the first and second plates 4, 6. Thereafter, it flows through the EGR gas passages 18, 25 formed in the first and second plates 4, 6, and is then discharged and distributed into the intake passages 24 through the EGR gas outlet ports 27 formed  
20 in the recesses 25a of the second plate 6 and located at the lowest portions thereof.

                  During the above-mentioned flowing of the EGR gas, when condensed water from steam in the EGR gas attaches to the EGR gas intake passages 18b, 25b, it  
25 flows down into the recesses 18a, 25a since the EGR gas intake passages 18b, 25b are inclined downward to the downstream side, thereby it is possible to prevent the condensed water from collecting.

Further, condensed water which attaches to the EGR inflow passages 18, 25 flows down into the recesses 18a, 25a, thereby it is also possible to prevent the condensed water from collecting.

5 Further, the condensed water having flown down in the recesses 18a, 25a is carried away by the stream of the EGR gas, and is then discharged into the intake passages 24, and accordingly, it is prevented from collecting in the recesses 18a, 25a.

10 Further, the bottom surfaces 25c of the recesses 25c are formed so as to be inclined downward on the front surface 6a side in the engine assembly condition, and are formed in its lowest portions with the EGR gas outlet ports 27, and accordingly, the  
15 condensed water can be surely drained. That is, if both plates 4, 6 are assembled to the cylinder head 2, being inclined with respect to the horizontal plane L, as shown in Fig. 7C, the bottom surfaces 18c, 25c of both recesses 18a, 25a are sloped downward toward the  
20 EGR gas outlet ports 27, thereby it is possible to carry out drainage of the condensed water more surely.

Next, explanation will be made of the relationship among the EGR gas inflow passage 13 in the first plate 4, the communication hole 19 in the first  
25 metal gasket 5 and the EGR gas inflow passage 23 in the second plate 6 with reference to Figs. 8A to 9B.

As mentioned above, in such a configuration that the first plate 4 and the second plate 6 are

provided, it is required to prevent the condensed water from collecting in the EGR inflow passages 13, 23 in the first and second plates 4, 6.

However, should the first metal gasket 5 be arranged out of alignment so that the bottom surface 19a of the communication hole 19 formed therein is lower than the bottom surfaces 13a, 23a of the EGR gas inflow passages 13, 23 formed in both plates 4, 6, as shown in Figs. 9A, 9B, there would be caused such a problem that the condensed water W collects on the bottom surface 19a of the communication hole 19, and accordingly, it cannot be drained, as shown in Fig. 9A.

Thus, according to the present invention, as shown in Figs. 8A, 8B, there is provided such a configuration that the bottom surface 19a of the communication hole 19 in the first metal gasket 5 is lower than the bottom surface 23a of the EGR gas inflow passage 23 in the second plate 6, and the bottom surface 13a of the EGR inflow passage 13 in the first plate 4 is lower than the bottom surface 19a of the communication hole 19 in the first metal gasket 5.

With this configuration, EGR gas flows in the direction of the arrow X, and accordingly, condensed water attaching to the bottom surface 23a of the EGR inflow passage 23 in the second plate 6 flows down onto the bottom surface 19a on the first metal gasket 5 side, as indicated by the arrow Y. Further, the condensed water attaching to the bottom surface 19a

flows down onto the bottom surface 13a on the second plate 4 side. Thus, the condensed water can be prevented from collecting in the first metal gasket 5 and the second plate 6.

5                Fig. 10 shows a second embodiment according to the present invention.

              In the second embodiment, EGR gas outlet ports 27a are formed in the recesses 18a of the EGR gas passage 18 in the first plate 4 of the first  
10    embodiment, being located in the lowest portions thereof, and being communicated with the respective intake passages 11, and a metal gasket 40 similar to the second metal gasket 7 is arranged, instead of the first metal gasket 5 of the first embodiment. Further,  
15    the metal gasket 40 is temporarily fixed to the first plate 4 by means of the pins 31 and the toothed washers 32 as stated above.

              In this second embodiment, the second plate 6 and the first metal gasket 5 in the first embodiment  
20    are eliminated, and the rear side of the EGR gas passage 18 in the first plate 4 is closed by the metal gasket 40.

              The configuration of the embodiment is the same as that of the first embodiment, except those as  
25    mentioned above, and accordingly, like reference numerals are used to denote like parts to those stated above. Thereby, explanation thereto will be omitted.

              Even in this second embodiment, EGR gas can



prevent the condensed water from collecting in the EGR gas passage 18 in the first plate 4 so as to discharge the condensed water from the EGR gas outlet ports 27a into the intake passages 11.

5                    Fig. 11 shows a third embodiment according to the present invention.

                  In the third embodiment, the body housing 8a of the EGR valve 8 in the second embodiment is integrally incorporated with the first plate 4, being  
10    made of metal.

                  The configuration of the third embodiment is the same as that of the second embodiment except that mentioned above, and accordingly, like reference numerals are used to denote like parts to those of the  
15    second embodiment. Thus, the explanation thereto will be omitted.

                  In the third embodiment, technical effects and advantages similar to those of the second embodiment can be exhibited, and as well, due to the  
20    integral incorporation of the body housing 8a of the EGR valve 8 and the first plate 4, the third metal gasket 12 and the bolt 35 can be eliminated, thereby it is possible aim at reducing the cost and facilitating the assembly thereof.

25                    Thus, according to the present invention, condensed water in the plates can be surely discharged into the intake passages, thereby it is possible to prevent the plates from being corroded by the condensed

- 17 -

water collecting.